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REPORT R-1643

COMBUSTIBLE AMMUNITION FOR SMALL ARMS

II. DEVELOPMENT OF A COMBUSTIBLE SMALL ARMS CARTRIDGE

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ABSTRACT

Combustible 7.62 mm ammunition, consisting of a molded integral propellant charge and a dual primer, was developed. When fired in a self-obturating 7.62 mm test weapon over the temperature range -65° to 160° F, this cartridge yielded mean ballistic performance similar to that obtained with the standard M59 metal cased cartridge. Velocity reproducibility, however, was poorer than that obtained with the standard cartridge. Accuracy was slightly less with the combustible ammunition.

The combustible dual primer, which consisted of a percussion sensitive cap and a pellet of standard styphnate primer mixture, provided adequate and reproducible ignition. Previous attempts to develop a combustible primer based upon the conventional cup and anvil system were unsuccessful.

Molded charges were found to have a considerable degree of inherent moisture resistance. Water immersion tests revealed no substantial changes in velocity or pressure after ten months exposure. Firings were conducted with molded charges coated with various materials to determine the degree of consumption of the coatings. All coatings were consumed, leaving no significant deposits. Impact of 7.62 mm rifle bullets did not cause deflagration of combustible cartridges. Mechanical testing of molded charges was conducted to determine single shear, tensile, and compression strength. The effect of temperature on dimensional changes was found to be sufficiently small, indicating this does not constitute a serious problem.

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INTRODUCTION

Previous studies conducted under this program resulted in the development of a self-contained, integral propellant charge for 7.62 mm ammunition(1)*. When used in conjunction with a primed metal case stub, these charges yielded performance meeting the ballistic requirements for the M59 cartridge. The integral charge consisted of IMR 4895 granular propellant molded in a configuration similar to that of the 7.62 mm brass case. Nitrocellulose (pyroxylin) dissolved in ether-alcohol was used as the binder.

The metal case stub (0.50 in. long) provided both ignition and partial obturation. Additional obturation was obtained by modification of the conventional Universal 7.62 mm test action. While suitable for the semicombustible round (i.e., metal case stub), this test action was not compatible with a fully combustible cartridge, which requires a breech obturating weapon. Consequently, the development of a combustible cartridge actually involved two problems: cartridge development and development of a self-obturating test weapon.

RESULTS AND DISCUSSION

A 7.62 mm test weapon, designed to provide breech obturation, was fabricated. This weapon, based upon the Springfield type receiver, provided for rear loading. Obturation was obtained by a step-wise sealing arrangement between the rear of the chamber and the screw-on head. A drawing of the test action, designated Model 1, is presented in Figure 1. Headspace was adjusted to 1.629 in., which is 0.001 in. above the permissible minimum. This was done to secure maximum firing pin penetration of the primer.

*See References

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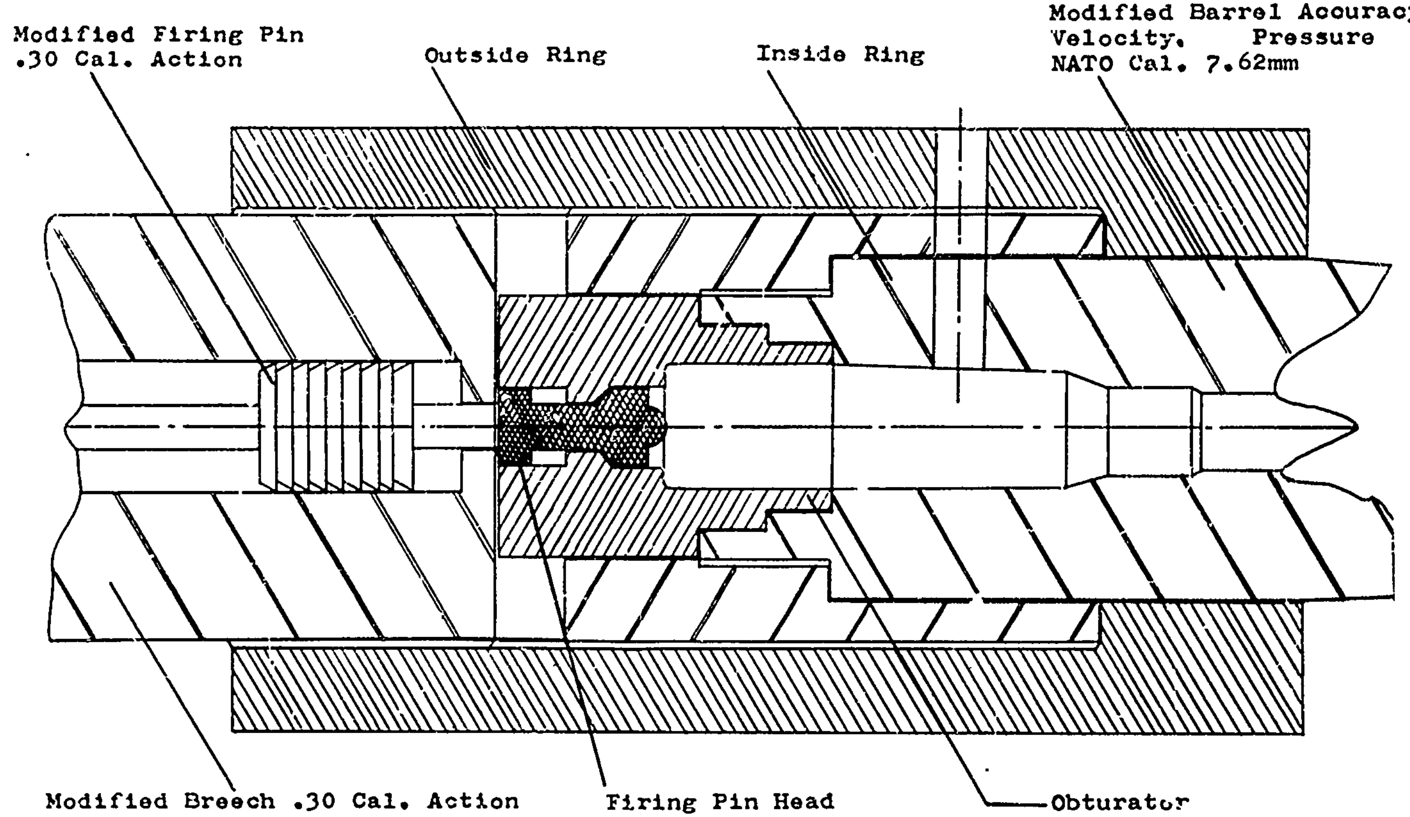

Figure 1. Model 1 Test Action

Metal Primer

Cartridges were prepared in which the 0.50 inch metal case stub (described in reference 1) was discarded. Since a combustible primer was not available at this time, a presensitized No. 34 metal primer (styphnate composition) was used. The primer, previously pressed on a flat surface to obtain sensitization, was inserted in a pocket provided in the base of the molded charge, which was prepared in the manner described in reference 1. This arrangement is illustrated in Figure 2. A small vent connected the primer pocket with the longitudinal perforation in the molded charge. Discarding the metal case stub required an increase in the length of the molded charge in order to maintain the configuration of the standard cartridge. The diameter of the longitudinal perforation in the molded charge was also increased to keep the charge weight constant.

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Figure 2. Semicombustible Cartridge

Firings were conducted with these semicombustible cartridges (containing the No. 34 metal primer) at 70° F in the Model 1 test action. Charge weights of 59 and 60 grains IMR 4895 AL 41024 propellant were employed. A description of this propellant lot (used in all tests described in this report) is given in the Appendix. Peak pressures were determined with a piezoelectric gage. Propellant ignition time and barrel time were read from the pressure-time trace. A paper screen was placed 15 feet from the muzzle to determine whether any unburned propellant was ejected. Visual observation of the extent of muzzle and breech flash was made. The results obtained in these firings are given in Table I.

Table I. Results of Firings with No. 34 Metal Primer (Semicombustible Ammunition) in Model 1 Test Action

No. of tests:	1st series - 22;	second series - 10.
No. of misfires:	1st series - 12;	second series - 1.

IMR 4895 Charge Weight (gr)	Velocity at 78 ft (fps)	Peak Pressure (piezo) (psi)	Time (msec) Propellant Ignition	Barrel
59.0	2593^{4}	$35,700^{4}$	0.36^{5}	1.87^{5}
Std Dev	137	5,000	0.15	0.15
60.0	2587^{10}	$39,700^{7}$	0.42^{9}	1.76^{8}
Std Dev	173	5,700	0.34	0.21

NOTES: Superscripts indicate number of values constituting average.

The primer was initiated and the molded charge was completely consumed in ten of 22 firings. Orange muzzle flash was observed. While no breech flash was visible, smoke was found to be emanating from the breech several seconds after firing. The paper screen indicated no unburned propellant was ejected.

Repeat firings were then attempted with ten of the twelve cartridges in which the primer had originally misfired. (Two were not tested due to primer dislodgment). Nine of the ten cartridges in the repeat test fired. Ballistic performance, including smoke and flash characteristics, were similar to those previously observed. The substantially higher percentage of firings in the repeat series suggested that the primer had not been sufficiently sensitized by the method employed - pressing on a flat surface. Primers are usually sensitized in the metal cartridge case by pressing them into the case pocket, which is of a slightly smaller diameter than the primer. This results in radial compression of the cup, which further compresses the primer mixture by reducing the distance between the anvil and the base of the cup, thus increasing sensitivity.

In the original series, very light primer indents had been noted. This indent on the misfired rounds apparently further sensitized the primers, causing them to be more easily initiated in the repeat series.

While the average ballistics obtained with the semicombustible ammunition approached that of the standard, uniformity with the former was poor. Lack of adequate reproducibility might be due to variations in the cartridge, e.g., molding pressure, rate of fragmentation of the molded charge, and/or variations in the degree of obturation in the test action (breech smoke was observed in many of the firings).

To determine whether the misfires with the No. 34 metal primer could be eliminated by more efficient sensitization, a split die (Figure 3) was fabricated which duplicated the primer pocket of the standard 7.62 mm metal case. The primers were pressed into this pocket and then removed by opening the die. Semicombustible ammunition was then assembled with these primers, and firings were again conducted at 70° F using the Model 1 test action. The results are given in Table II.

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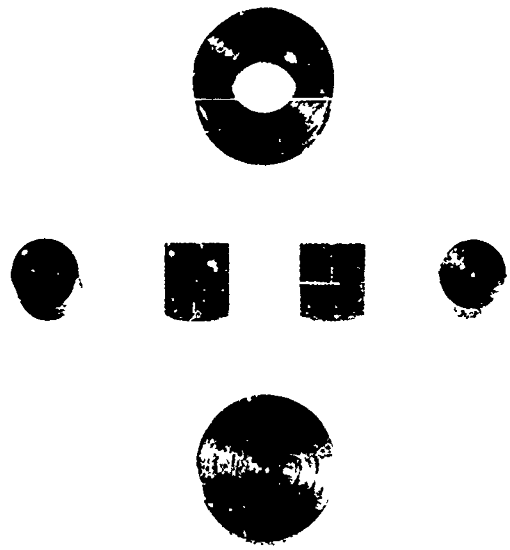

Figure 3. Split Die for Sensitizing #34 Primer

Table II. Results of Firings with No. 34 Metal Primer Sensitized in Simulated Primer Pocket (Semicombustible Ammunition) in Model 1 Test Action

No. of tests - 9; No. of misfires - 6

IMR 4895 Charge Weight (gr)	Velocity at 78 ft (fps)	Peak Pressure (piezo) (psi)	Time (msec) Propellant Ignition	Barrel
59.0	2603	37,800	0.30	1.48
Std Dev	36	1,100	0.01	0.02

Of the nine cartridges tested, only three fired. Primer misfires were encountered with the balance. Thus, no reduction in the frequency of misfires was attained by pressing the metal primers in a simulated primer pocket. The average ballistic performance of those rounds which fired was similar to that obtained previously (Table I). Uniformity appeared to be better, but it should be noted that the data in Table II represent only three firings.

Several possible explanations might be suggested for this inability to reduce the frequency of primer misfires: (1) The metal primer with its relatively sharp cup edges moved forward into the molded charge primer pocket. (2) The anvil was dislodged from the cup when struck by the firing pin. (3) Pressing in the simulated primer pocket did not effect the desired sensitization since any radial compression might disappear when the die is released; this would result in the cup reverting to its normal diameter and increasing the minimum thickness of the primer mixture.

At this stage, combustible primer development had progressed to the point where a nonmetallic primer was available for test. As a result, further studies with the No. 34 metal primer were discontinued.

Nonmetallic Primer Components

A percussion sensitive, nonmetallic primer (based upon the cup and anvil system) should have components capable of absorbing the impact of the firing pin without crumbling. In addition, all components must burn or be pulverized completely during the ballistic cycle. The primer should fire under approximately the same impact as that required by a conventional primer.

In the following investigations, nonmetallic primer components of various compositions were prepared by machining to the desired dimensions. These components were assembled using a charge of 0.5 grain standard FA 956 lead styphnate priming composition.

Nitrocellulose-Camphor Primer Components. The first investigations involved the fabrication of cups and anvils from a very hard, low nitrogen nitrocellulose-camphor composition. These were made to approximately the same configuration as that of the standard metal primer. The inner base of the cup and the conical surface of the anvil were coated with 250/325 mesh zirconium to increase sensitivity. Coating was accomplished by wetting the surfaces with acetone and then applying the fine zirconium metal. The primer components were charged with the styphnate primer mixture and sensitized by assembling under compression. The minimum thickness of the primer mixture (distance between the anvil and cup base) was similar to that of a sensitized metal primer. Combustible cartridges were then assembled by loading the primer in the pocket provided in the rear of the molded charge. The individual values obtained in firings at 70° F in the Model 1 test action are given in Table III.

Table III. Results of Firings with Nitrocellulose-Camphor Primer Components (Combustible Ammunition) in Model 1 Test Action

No. of tests - 5; No. of misfires - 1

IMR 4895 Charge Weight (gr)	Velocity at 78 ft (fps)	Peak Pressure (piezo) (psi)	Time (msec) Propellant Ignition	Barrel
58.0	2643	40,600	0.65	2.05
60.0	2781	46,300	0.30	1.55
60.5	2805	46,300	0.25	1.55
62.0	2898	50,800	0.30	1.60

While this performance approximated that of the standard metal cased cartridge, the nitrocellulose-camphor primer cups and anvils underwent no detectable change. No burning or fragmentation was noted in those components recovered. Thus, even though the nitrocellulose-camphor primer components offered promise in regard to initiation (four out of five fired), the relative inertness of the composition did not warrant further evaluation.

Nitrocellulose-Nitroglycerin Primer Components. Since the previous firing had indicated a need for primer components that are more ignitable and combustible, the use of double base propellants as primer components was investigated. Primer cups were made from two double base propellants, RAD-470-44 and IXM-51, to the same configuration as the standard primer.

Since the primary objective was to determine whether the cups would be consumed, primers were assembled with metal anvils which, it was believed, would increase the probability of functioning. The primers were sensitized by loading under compression after the base of the cup was coated with fine zirconium powder. To combat the possible problem of dislodgment of the anvil upon being struck by the firing pin, the manner of drilling the primer pocket was changed. The pockets of all previous molded charges were prepared using a standard drill, resulting in a V-shaped bottom surface. To present a flat bottom so that the anvil would not move forward, these and all subsequent charges were prepared using a flat bottom drill. The primer thus rested firmly on the bottom of the pocket.

Firings were conducted at 70° F in the Model 1 test action. The results are in Table IV.

Table IV. Results of Firings with Nitrocellulose-Nitroglycerin Primer Cups (Combustible Ammunition) in Model 1 Test Action

RAD-470-44 Propellant: No. of tests - 3; No. of misfires - 0
IXM-51 Propellant: No. of tests - 3; No. of misfires - 1

IMR 4895 Charge Weight (gr)	Primer Cup Component	Velocity at 78 ft (fps)	Peak Press (piezo) (psi)	Time (msec) Propellant Ignition	Time (msec) Barrel
59.0	RAD-470-44	2699	42,800	0.55	1.87
Std Dev		14	900	0.19	0.17
58.5	IXM-51	2453	34,200	0.50	1.98
Ext Var		24	900	0.20	0.25

With all rounds that fired, the primer cups shattered into many small pieces. Examination of the chamber and barrel revealed varying quantities of residue, ranging from a small to a considerable fraction of the original primer cup. The residual pieces retained their original appearance, indicating the partial consumption was due more to the frangible nature of the cup (with the resulting small pieces ejected from the muzzle during the ballistic cycle) than to combustion.

To increase the degree of consumption, primer cups and anvils were fabricated from two fast burning double base compositions, M2 (77.45% nitrocellulose/19.50% nitroglycerin) and M5 (81.95% nitrocellulose/15.00% nitroglycerin). These compositions appeared relatively hard and could be easily machined. Cups and anvils were fabricated, the former to the same dimensions as were the previous double base cups. The components were charged with the 0.5 grain FA 956 styphnate pellet and sensitized by loading under compression. Other primers were similarly prepared except that zirconium coatings were applied to the cup base and anvil cone to increase sensitivity. Combustible cartridges were then loaded with these primers and firings conducted at 70° F in the Model 1 test action. None of the primers assembled with M5 components fired. The results with M2 components are in Table V. Barrel times were missed in several firings due to muzzle break wire failure.

Table V. Results of Firings with M2 Primer Components (Combustible Ammunition) in Model 1 Test Action

M2 Composition: No. of tests - 15; No. of misfires - 10
M2-Zr Composition: No. of tests - 5; No. of misfires - 2

IMR 4895 Charge Weight (gr)	Primer Component	Velocity at 78 ft (fps)	Peak Press (piezo) (psi)	Time (msec) Propellant Ignition	Time (msec) Barrel
59.0	M2	2396[3]	32,400[4]	1.43[4]	2.15[1]
Std Dev		72	4,400	0.91	-
53.0[a]	M2-Zr	1937	23,400	0.50	2.40
56.0[a]	M2-Zr	2320	33,500	0.50	2.20
58.0[a]	M2-Zr	2660	47,700	0.95	2.45

NOTE: Numerical superscripts indicate number of values constituting average; a indicates individual values.

Use of M2 components yielded only five firings out of 15 attempts. Ignition was also unsatisfactory with those M2 components coated with zirconium (three firings out of five attempts). The primer components were almost completely consumed in those rounds that fired. This improvement in degree of consumption, however, was overshadowed by the high frequency of misfires. Apparently the system was not sufficiently rigid to compress the primer mixture between the firing pin and anvil. To obtain still harder components, the use of single base propellant was next investigated.

<u>Nitrocellulose Primer Components.</u> Primer cups and anvils were made from single base composition (99% nitrocellulose) to the same dimensions used with the double base components. The stick propellant from which the components were made was extremely hard and could be readily machined. As before, the primers were charged with the standard 0.5 grain styphnate pellet and loaded under compression. The primer was then inserted in the primer pocket of the combustible cartridge and firings were conducted at 70° F in the Model 1 test action. The results are given in Table VI. Pressure-time traces were recorded in only two of seven firings due to long propellant ignition times.

Table VI. Results of Firings with Nitrocellulose Primer Components (Combustible Ammunition) in Model 1 Test Action

No. of tests - 7; No. of misfires - 0

IMR 4895 Charge Weight (gr)	Velocity at 78 ft (fps)	Peak Pressure (piezo) (psi)	Time (msec) Propellant Ignition	Time (msec) Barrel
58.5	2385^{7}	$36,800^{2}$	0.88^{2}	2.20^{1}
Std Dev	177	-	-	-

NOTE: Superscripts indicate number of values constituting average.

All seven cartridges fired; however a considerable portion of the cup and the virtually intact anvil were recovered after each firing. The components either did not ignite or did not burn rapidly enough to be completely consumed during the ballistic cycle. One possible solution to this problem might be a reduction in the wall and base thickness of the cup. This, however, would affect the physical strength. As for the anvil, it might be perforated so that it would perform its intended function and still be consumed.

While it was believed that a satisfactory combustible cup and anvil system could be developed, the immediate prospects appeared poor. As a result, it was decided to shelve this concept and approach the problem of initiation from a different aspect.

Dual (Cupless) Primer

The approach selected was based on a primer containing neither cup nor anvil. This concept involved a dual primer system, wherein a standard styphnate pellet (0.5 grain) was loaded in the primer pocket of the combustible cartridge and a commercially available percussion sensitive cap (approximately 0.08 grain and 0.185 inch diameter) was bonded to the styphnate pellet. To retain the pellet in the primer pocket, the vent connecting the latter with the main longitudinal perforation was eliminated, completely sealing the pocket. The cap consisted of approximately 46% potassium chlorate, 49% antimony sulfide, 4% red phosphorous, 0.3% magnesium carbonate, and 0.7% gum tragacanth. In view of the high sensitivity of this cap, the primer pocket was of such a depth that the cap was recessed below the surface of the combustible cartridge. The dual primer, as it finally evolved, is illustrated in Figure 4.

In preliminary firings the cap, which had a paper backing, was cut and affixed to the cartridge in such a manner as to yield a disc equal to the diameter of the cartridge. Since the percussion sensitive cap was approximately 40 percent of this diameter, the outer portions of the disc consisted solely of the paper backing. Firings were conducted at 70° F in the Model 1 test action with four combustible cartridges assembled with the above dual primer system. All four fired.

A small amount of paper residue from the cap was noted after each firing. Since the amount of paper surrounding the caps could easily be reduced by trimming, this presented no serious problem. The percussion sensitive caps used in subsequent combustible cartridges were all carefully trimmed to keep the amount of surrounding paper to a minimum.

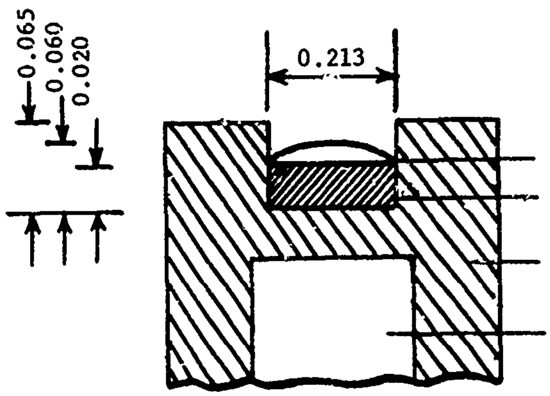

Figure 4. Dual Primer

To evaluate this system further, additional firings were conducted with the combustible cartridge (dual primer) at 70° F in the Model 1 test action. The results are given in Table VII.

Table VII. Results of Firings with Dual Primer (Combustible Ammunition) in Model 1 Test Action

No. of tests - 9; No. of misfires - 0.

IMR 4895 Charge Weight (gr)	Velocity at 78 ft (fps)	Peak Pressure (piezo) (psi)	Time (msec) Propellant Ignition	Barrel
58.0	2489^{9}	$38,800^{6}$	0.75^{6}	2.34^{6}
Std Dev	154	4,800	0.32	0.33

NOTE: Superscript indicate number of values constituting average.

Again, all cartridges fired. Complete consumption was obtained in all firings, with no paper residue as in the previous series. Although mean velocity was substantially below the required 2750 fps level, the mean pressure was correspondingly low. There was still, however, the problem of poor reproducibility.

Pressure-time traces were missed in three firings due to long propellant ignition times. The large variation in this parameter suggested that the effect of ignition upon reproducibility be investigated. One possibility was that the standard 0.5 grain FA 956 primer pellet was not sufficient to reproducibly ignite and fragment the integral molded charge. Consequently, cartridges were assembled with the molded IMR 4895 charge and the dual primer consisting of the percussion sensitive cap and styphnate primer pellet weights of 0.60, 0.80, and 1.00 grain. Firings were conducted at 70° F in the Model 1 test action. The results are in Table VIII. For comparison, the results obtained with the 0.5 grain primer pellet previously used are included.

Table VIII. Effect of Primer Pellet Weight upon Ballistic Performance of Combustible Ammunition with Dual Primer, in Model 1 Test Action

No. of tests - 28; No. of misfires - 0

Weight (gr)			Velocity	Peak Press	Time (msec)	
IMR 4895 Charge	Styphnate Pellet	No. of Rounds	at 78 ft (fps)	(piezo) (psi)	Propellant Ignition	Barrel
58.0	0.50	9	2489	38,800	0.75	2.34
Std Dev			154	4,800	0.32	0.33
59.0	0.60	9	2743	44,900	0.54	2.02
Std Dev			99	6,400	0.30	0.28
59.0	0.80	5	2644	40,900	0.20	1.66
Std Dev			147	1,900	0.00	0.04
59.0	1.00	5	2661	37,400	0.26	1.80
Std Dev			56	4,200	0.07	0.04

The 0.50 and 0.60 grain primer pellets yielded substantially longer propellant ignition times than did the 0.80 and 1.00 grain pellets. Uniformity of this parameter was also better with the two heavier weights. This indicates the 0.50 grain primer used previously did not provide adequate ignition.

The same relationship holds for the barrel time wherein the mean value was shorter and the uniformity better with the higher pellet weights.

The mean velocity obtained with the 0.50 grain primer was considerably less than that obtained with the other three primer weights even though the peak pressures were similar. It is realized that the 0.50 grain primer was used with a 58.0 grain propellant charge and the others with 59.0 grains. However, this slight difference in propellant weight cannot account for the considerable velocity difference. Mean velocities obtained with the 0.60, 0.80, and 1.00 grain pellets were similar and all in the range of velocities yielded by standard metal cased ammunition. Mean peak pressures (piezoelectric) with all four pellet weights were lower than obtained with the standard ammunition, approximately 54,000 psi (piezoelectric).

Thus, uniformity was increased and performance improved with the heavier primer pellet weights. However, uniformity was still not equal to that of the metal cased ammunition. The 0.80 grain styphnate pellet was selected for further evaluation since this represented the minimum weight yielding both short propellant ignition times and acceptable reproducibility of this ballistic value.

The insensitivity of velocity reproducibility to primer weight suggested that this problem was attributable more to gas leakage in the Model 1 test action than to inherently nonreproducible consumption rates of the combustible ammunition. The fact that this test action was not completely gas-tight had been established previously. Breech sparking was observed in most firings. It was not known, however, whether this leakage was constant or varied from round to round.

While the primer development was proceeding, a self-obturating test action was designed and fabricated under a parallel project.* This test action obturates by means of a "reverse tapered"

*Project TS1-2, "Direct Fire Ammunition for the All Purpose Hand Held Weapon."

firing pin and the bottoming of the barrel against the action (Figure 5). Success of this action led to its use in this program. A 7.62 mm barrel was therefore attached to this action (designated Model 2).

Charge establishment firings were conducted at 70° F with the combustible cartridges to determine the optimum charge in the Model 2 test action. Cartridges were assembled with different charge weights of IMR 4895, a nominal styphnate pellet weight of 0.8 grain, and the percussion sensitive cap. The results obtained are given in Table IX.

Table IX. Results of Charge Establishment Firings with Combustible Ammunition Containing Dual Primer, in Model 2 Test Action

No. of tests - 15; No. of misfires - 0

IMR 4895 Charge Weight (gr)	No. of Rounds	Velocity at 78 ft (fps)	Peak Press (piezo) (psi)	Time (msec) Propellant Ignition	Time (msec) Barrel
57.0	5	2641	37,900	0.12	1.44
Std Dev		63	3,900	0.04	0.12
58.0	5	2752	43,300	0.18	1.44
Std Dev		100	4,700	0.07	0.14
59.0	5	2772	44,100	0.13	1.30
Std Dev		94	3,700	0.04	0.07

The mean velocities obtained with the 58.0 grain IMR 4895 - 0.8 grain primer combination were slightly higher than those obtained previously in the Model 1 test action. Propellant ignition times and barrel times were correspondingly shorter. While velocity uniformity appeared to be slightly better compared with that obtained in the earlier test action, there was still room for improvement. All rounds fired with no residue obtained, further indicating the reliability of the dual primer. On the basis of the above results, the 58.0 grain IMR 4895 charge, which yielded a mean velocity of 2752 fps, was selected.

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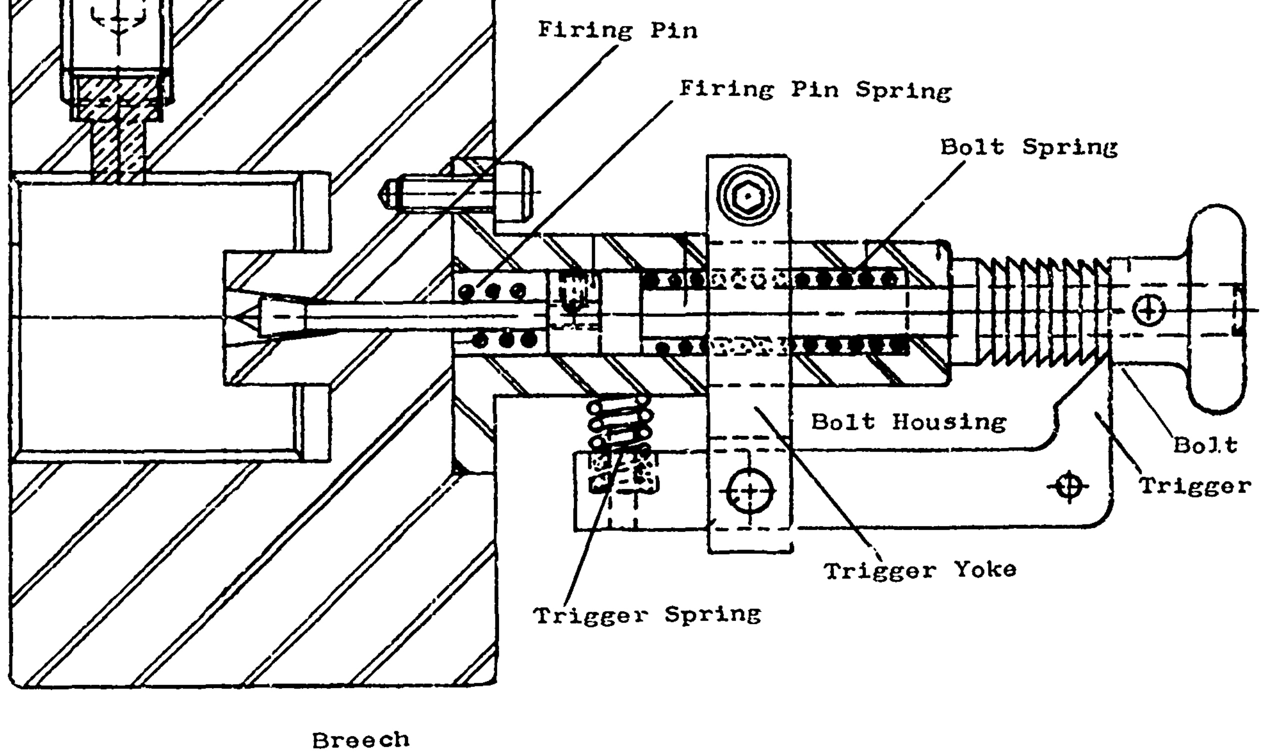

Figure 5. Model 2 Test Action

Extreme Temperature Ballistics. The extreme temperature ballistics of the above combustible cartridge were determined at -65°, 70°, and 160° F in the Model 2 test action. Cartridges were assembled with an average charge of 57.6 grains molded IMR 4895 propellant, an 0.8 grain pellet of FA 959 styphnate primer mixture, and the percussion sensitive cap. The cartridges were conditioned for two hours at the specified temperatures prior to firing. Pressures were determined with copper crusher cylinders and piezoelectric gages. The results are presented in Table X. The construction of the action (which resulted in fouling, slowing the forward motion of the firing pin) made it difficult to get satisfactory sweep initiation on the oscilloscope. Consequently, a considerable number of pressure-time traces were missed.

Table X. Extreme Temperature Ballistics of Combustible Ammunition with Dual Primer, in Model 2 Test Action

No. of tests - 70; No. of misfires - 0

Temp (°F)	No. of Rounds	Velocity at 78 ft (fps)	Peak Pressure (psi) Copper Crusher	Peak Pressure (psi) Piezo-electric	Time (msec) Propellant Ignition	Time (msec) Barrel
70	10	2805	51,200	-	-	-
Std Dev		56	7,500	-	-	-
70	20	2800	-	$47,000^{8}$	0.49^{7}	1.90^{6}
Std Dev		62	-	4,600	0.30	0.34
160	10	2847	55,000	-	-	-
Std Dev		59	4,500	-	-	-
160	10	2888	-	$51,700^{6}$	0.21^{6}	1.53^{6}
Std Dev		39	-	3,500	0.05	0.06
-65	10	2740	46,400	-	-	-
Std Dev		83	5,400	-	-	-
-65	10	2783	-	$49,400^{2}$	0.25^{2}	1.60^{2}
Std Dev		73	-	-	-	-

NOTE: Superscripts indicate number of values constituting average. If superscript is not indicated, average is based upon full number of rounds fired.

The mean velocity at 70° F was slightly above that of the 7.62 mm metal cased specification of 2750 ± 30 fps. While the mean pressure, as measured with copper crusher cylinders, also exceeded the 50,000 psi specification, the mean piezoelectric pressure was below the permissible maximum. In those firings where copper crusher cylinders were used, the mean velocity and pressure spreads over the range -65° to 160° F were 107 fps and 8600 psi, respectively. In the firings where piezoelectric gages were used, the velocity spread was 105 fps. These velocity and pressure spreads are of the order of those obtained with 7.62 mm metal cased M59 ammunition. All rounds functioned at the three temperatures with no evidence of incomplete consumption, further confirming the reliability of the dual primer. Uniformity was slightly better than obtained previously in the Model 1 test action, but still needed improvement.

The most important fact to be gleaned from the extreme temperature firings was that the combustible cartridge functioned satisfactorily over the complete temperature range and yielded mean velocity and pressure spreads similar to those obtained with the standard metal cased cartridge.

Muzzle Flash. Photographs were taken during the extreme temperature firings to determine the extent of breech and muzzle flash. No breech flash was noted. However, a considerable amount of muzzle flash was observed originating approximately one foot forward of the muzzle, at a point where a heavy wall (with opening through which the projectile passes) separated the range and the firing room. The flash was not of conventional gaseous type, but consisted rather of sparklers, indicative of burning propellant grains.

Accuracy. Accuracy obtained with the combustible cartridge in the Model 2 test action was also determined in the course of the extreme temperature firings. A paper screen, mounted 101 yards from the muzzle (the maximum length of the indoor range used in these tests) was used. For comparison, accuracy firings were also conducted with standard 7.62 mm M59 cartridges (Lot FAY 7.62-435, WC 846.3 AL 40633 propellant, Rem 39 primer) using a conventional 7.62 mm receiver. Accuracy values with the combustible cartridges represent average target measurements based on two 10-round groups at each temperature. The values for the standard cartridge represent one 10-round group at each temperature. The results are given in Table XI.

Table XI. Results of Accuracy Firings with Combustible and Standard Ammunition

	Target Measurement (in.)					
	Combustible Ammo			Standard Ammo		
	70°F	160°F	-65°F	70°F	160°F	-65°F
Mean vertical deviation	0.8	0.9	1.1	0.5	0.7	0.4
Mean horizontal deviation	0.8	0.4	0.8	0.5	0.5	0.5
Mean radius	1.3	1.2	1.5	0.8	1.0	0.8
Extreme vertical spread	2.9	3.8	5.0	2.9	2.7	2.4
Extreme horizontal spread	3.5	2.3	2.7	1.5	1.9	2.0
Extreme spread	4.3	3.8	5.2	3.2	3.1	2.6

While the combustible cartridge yielded poorer accuracy than did the standard, the difference was not great. The greater vertical deviation obtained with the combustible cartridge was due to its higher velocity dispersion. Examination of the paper target revealed no evidence of keyholing with the combustible cartridge.

Drop Test Studies with Dual Primer

Extensive firings with the dual primer in the combustible cartridge have proven it to be a reliable ignition system. Little was known, however, regarding its sensitivity except the belief that the dual primer was considerably more sensitive than the standard percussion primer used in the metal cased round. For this reason, the percussion sensitive caps were recessed below the surface of the combustible cartridge.

Primer drop tests were conducted to determine the sensitivity of the dual primer. Inert molded charge stubs were prepared to have the same general physical characteristics as the combustible cartridge. An 0.8 grain styphnate primer pellet (FA 956 and FA 959 mixtures) and cap were loaded into the primer pocket of the inert stub. A two-ounce (nominal) weight ball falling on a firing pin with an 0.018 inch flat (refer to Figure 6) was used to provide the impact energy. Misfires were retested at the next higher heights until functioning occurred. The results are given in Table XII.

NOTE: Specifications for the standard 72M primer used in 7.62 mm ammunition require that with a 4-oz ball, the all-fire height $\bar{H} + 5\sigma$ shall be less than 15 inches. In addition, the value of $\bar{H} - 2\sigma$ shall not be less than two inches. $\bar{H}$ is defined as the average height at which 50 percent of the primers fire.

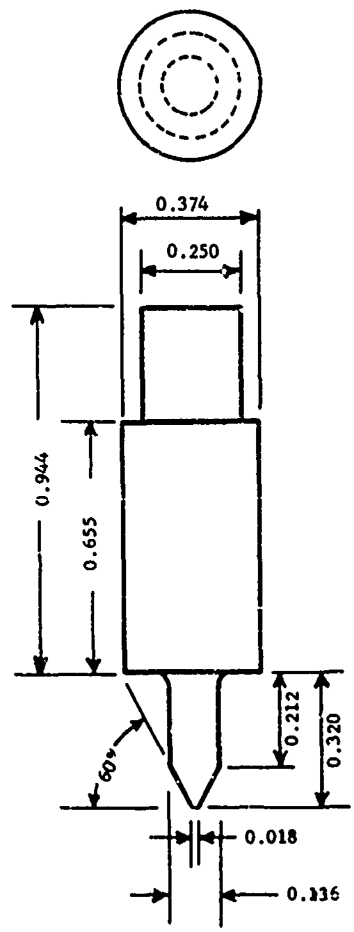

Figure 6. Firing Pin for Primer Sensitivity Drop Tests

Table XII. Results of Drop Tests with Dual Primers

Primer	Drop Height (in.)	Results	
		Fired	Misfired
FA 956 mixture + cap	2.0	5	2
	2.5	8	3
	3.0	5	3
	3.5	6	1
	4.0	2	0
FA 959 mixture + cap	2.5	1	4
	3.0	6	2
	3.5	3	0

While no statistical interpretation can be made due to limited sample size, the high sensitivity of the dual primers is evident. Those containing the FA 959 primer mixture appeared slightly less sensitive than those assembled with the FA 956 mixture.

To reduce the sensitivity of the dual primer, the percussion sensitive caps were covered with metal foil. Two types which offered promise of complete consumption in the test weapon, 0.005 in. thick magnesium and 0.003 in. thick aluminum, were used. Drop tests were conducted in the same manner described above. The results are shown in Table XIII.

Both the magnesium and aluminum foil served to decrease the sensitivity. It was found that both foils also gave protection to the firing pin, decreasing the amount of fouling in the firing pin mechanism. Neither foil was consumed in these tests, but it should be borne in mind that the tests were not conducted under confinement. However, limited firings conducted in the Model 2 test action using dual primers covered with magnesium foil resulted in complete consumption of the metal disc.

In view of the reduction in sensitivity afforded by the metal foil, drop tests with the dual primer and magnesium disc were repeated, using a sample size of 120 primed stubs. The results are given in Table XIV.

Table XIII. Results of Drop Tests with Dual Primers containing FA 959 Mixture + Cap Covered with Metal Discs

Metal Disc Thickness (in.)	Metal Disc Foil	Drop Height (in.)	Results Fired	Results Misfired
0.005	Magnesium	4.0	0	1
		5.0	0	1
		5.5	1	0
		6.0	8	0
0.003	Aluminum	3.5	0	1
		4.0	3	2
		4.5	4	0
		5.0	2	0
		6.0	1	0

Table XIV. Results of Drop Tests with Dual Primers containing FA 959 Mixture + Cap covered with Magnesium Disc

Drop Height (in.)	Results Fired	Results Misfired
2.5	1	19
3.0	7	13
3.5	7	13
4.0	14	6
4.5	14	6
5.0	20	0

The skewed nature of the sensitivity curve did not permit determination of $\bar{H}$ by the usual method. However, the $\bar{H}$ value lies between 3.5 and 4.0 inches. Thus, while use of the magnesium disc reduced the $\bar{H}$ value of the dual primer, the resultant sensitivity was still higher than desired.

Impact Sensitivity of Molded Charges

Tests were conducted to determine whether the impact of a 7.62 mm rifle bullet would cause deflagration of the combustible cartridge. Individual molded IMR 4895 charges were placed in a wooden box having holes at opposite ends to permit passage of the bullet. This box was located 15 feet from the muzzle of a 7.62 mm test action used for the firings. Ten tests were conducted, nine with M59 ball bullets and one with an M62 tracer bullet. Each charge broke apart when struck by the bullet. While a small amount of smoke was noted in the box after each firing, no evidence of ignition or partial burning was observed.

In another test, ten molded charges were placed together in a small cardboard container which was then placed in the wooden box used previously. Four tracer and three M61 AP rounds were fired at this box at intervals of approximately two minutes. Examination revealed all ten molded charges were broken. However, there was no evidence of ignition or partial burning.

Impact sensitivity tests were conducted by the Bureau of Mines (2) on both molded and loose IMR 4895 propellant. Sample weights of approximately 50 mg were subjected to the impact energy of a 5 kg weight falling from selected heights on a steel firing pin. Tests were conducted to determine the height yielding a 50 percent ignition probability.

No significant difference was noted between the impact sensitivity of the molded and loose IMR 4895 propellant samples, the 50 percent ignition points being 29 and 28.5 cm, respectively. These values were substantially lower than those previously determined for such common explosives as PETN and RDX. The reason for this effect may be due to the nature of the test, wherein the formation of smoke was regarded as evidence of ignition. In no case was the propellant consumed. While the test indicates a high sensitivity for the experimental samples, it must be borne in mind that loose extruded single base propellant (e.g., IMR 4895) has been used in small arms ammunition for a considerable length of time without any serious problem due to impact sensitivity characteristics.

Physical Properties of Molded Charges

The physical properties of the combustible cartridge are of considerable importance since the cartridge must be able to withstand the severe forces to which it would be subjected in an automatic weapon, as well as the rough handling of shipment. Tests were therefore conducted to determine some of the physical properties of the molded propellant. The specimens used in this evaluation were molded IMR 4895 solid cylinders having outer dimensions similar to those of the 7.62 mm combustible cartridge, viz., 0.460 in. diameter and 1.585 in. length. The results are presented in Table XV.

Following are some general comments regarding the results of these tests.

(1) The molded cylinders have slightly elastic properties, i.e., they deflected under compression and then partly returned to original length when the load was released. It is probable that some compression also occurs when the combustible cartridge is struck by the firing pin. Consequently, a consumable primer used with the 7.62 mm combustible cartridge should have sufficient sensitivity to compensate for the deflection which would reduce the energy transmitted by the firing pin to the primer.

(2) The data for the single shear and compression strength tests were considerably more reproducible than the tensile strength values. The reason for this difference in reproducibility is not known.

(3) It should be noted that no dimensional changes were detected at temperatures up to 150° F. At 175° F and higher, increases in length up to 0.6 percent were obtained. Increases in diameter were small, with a maximum change of 0.4 percent at 250° F. It therefore appears that the effect of temperature upon dimensional changes does not constitute a serious problem.

It should be noted that the samples used in these tests were solid molded cylinders, unlike the perforated cylinders used in 7.62 mm combustible ammunition. This, however, does not affect the nature of the above observations.

Table XV. Results of Mechanical Testing of Molded Charges

A. Mechanical Properties

	Strength (psi)			Deflection at Max Compression Strength (in.)
	Single	Tensile	Compression	
Average	1390	2340	2270	0.088
Maximum	1570	4100	2330	0.091
Minimum	1200	820	2200	0.079
No. of samples	5	10	5	5
Application rate (in./min)	0.05	0.05	-	-

B. Effect of Pressure Load on Deflection

Pressure (psi)	Avg Deflection under Pressure (in.)	Avg Permanent Set after Pressure Release (in.)
600	0.022	0.007
1200	0.037	0.013
1800	0.055	0.022
2100	0.065	0.030

No. of samples - 5

C. Effect of Temperature on Dimensional Changes

Temp (°F)	Conditioning Time (min)	Avg Increase[a] (in.) in Length	Avg Increase[a] (in.) in Diameter
100	10	0.000	0.000
125	10	0.000	0.000
150	10	0.000	0.000
175	10	0.007	0.001
200	10	0.006	0.000
250	5	0.009	0.002

No. of samples -5

[a]Dimensions determined with micrometer while samples were at conditioning temperature.

Molded Charge Coatings

In the firing of a conventional metal cased cartridge, the extracted case removes heat. This removal of heat does not occur with the combustible cartridge. Consequently, the temperature developed in the chamber of an automatic weapon firing combustible ammunition may well be higher than that in a conventional weapon with metal cased cartridges. The requirement for a protective envelope to serve as a thermal barrier is evident. In addition, the envelope should protect the cartridge against environmental conditions (including water), fireproof the cartridge to protect against accidental lighting, serve as a lubricant to permit rapid feeding of the cartridge into the chamber of an automatic gun, and be completely consumed during the ballistic cycle without adversely affecting ballistic performance.

Several coating agents having one or more of the above attributes were selected for study. These were applied with a brush while rotating the molded charge in a lathe. The weight of coating required to give complete coverage varied from 0.5 to 2.0 grains depending upon the coating agent, and increased the diameter of the molded charge by 0.002 to 0.004 inch. The following coating agents were applied: Nylon, Teflon (uncured aqueous dispersion), yellow lacquer chromate (approximately 8 to 12 percent nitrogen nitrocellulose), Epon 828 (epoxy resin), 50/50 Epon 828 and Epon 562, Laminac (polystyrene), molybdenum disulfide, graphite, and methyl methacrylate.

Semicombustible cartridges, as described in reference (1), were assembled using these coated molded charges and 7.62 mm metal case stubs. Firings were conducted at 70° F to determine the degree of consumption of the different coatings. All of the coatings were consumed, leaving no significant deposits. The amount of dust remaining (determined by visual examination and by running a cleaning patch through the barrel after each firing) was either similar to or just slightly more than that obtained with the standard metal cased cartridge. More extensive firings were conducted with selected coatings to determine their effect upon ballistic performance. The results are shown in Table XVI.

Table XVI. Effect of Various Coatings upon Ballistic Performance of Semicombustible Ammunition in Modified Universal Test Action

Coating		Coating Weight (gr)	IMR 4895 Charge Weight (gr)	No. of Rds	Velocity at 78 ft (fps)	Peak Pressure (piezo) (psi)	Time (msec) Propellant Ignition	Time (msec) Barrel
Epon 828		1	58	5	2553	44,100	0.19	1.57
	Std Dev				113	4,900	0.07	0.09
Teflon		1	56	8	2750	48,200	0.35	1.53
	Std Dev				140	9,700	0.22	0.24
Methyl methacrylate crystal violet		1	57	4	2798	48,900	0.10	1.27
	Std Dev				76	3,900	0.00	0.05
Methyl methacrylate graphite		1	58	5	2680	46,300	0.40	1.64
	Std Dev				101	4,100	0.23	0.26
Molybdenum disulfide plus alkyd		1	57	5	2761	46,600	0.22	1.43
	Std Dev				70	4,400	0.05	0.03
Uncoated[a]		-	59	5	2739	49,600	0.52	1.75
	Std Dev				31	1,700	0.34	0.35

[a]See Reference (1)

All coatings were completely consumed in the ballistic cycle. Cleaning patches run through the barrel after each firing revealed no significant difference between the residual dust obtained with the various coated semicombustible cartridges and the standard metal cased cartridge. With the exception of the Epon 828 cartridge, the ballistic performance obtained with the coated semicombustible cartridges was similar to that yielded by the uncoated cartridge. The high standard deviations do not permit a more refined comparison.

It thus appears that consumability of the protective coating does not constitute a serious problem and that evaluation of the coatings should be based on other attributes, primarily thermal insulating properties.

Effect of Water Immersion upon Ballistic Performance

Among the attributes required of small arms ammunition is the ability to withstand extended long term storage under adverse environmental conditions without serious impairment of ballistic performance. Since the 7.62 mm combustible ammunition has no metal case to serve as a water-tight protective container, the capability to withstand water immersion was regarded as particularly important.

Tests were therefore conducted to determine the effect of extended water immersion upon the ballistic performance of semicombustible ammunition assembled with a nominal 55 grain IMR 4895 charge and a metal case stub. Since the molded charges used in these tests had no protective coating, the results indicate their inherent moisture resistance. After immersion, the molded charges were dried under a stream of air for eight hours and then at room temperature for one week. The cartridges were then assembled with metal case stubs and fired. The results are presented in Table XVII.

Standard deviations are not included in view of the limited number of firings for the individual exposure conditions. In general, however, reproducibility was of the same order as encountered previously. It is seen that no gross changes in mean velocity and pressure were induced by the extended water immersion. (The high mean pressure obtained after nine months' exposure is probably not significant.)

Table XVII. Effect of Extended Water Immersion upon Ballistic Performance of Semicombustible Ammunition in Modified Universal Test Action

Period of Water Immersion (mo)	Velocity at 78 ft (fps)	Peak Piezo Pressure (psi)	Time (msec)	
			Propellant Ignition	Barrel
2	2785^{3}	$46,900^{3}$	0.20^{3}	1.48^{2}
4	2705^{2}	$47,600^{2}$	0.88^{2}	1.75^{1}
5	2690^{2}	$44,300^{2}$	0.35^{2}	1.45^{1}
6[a]	2771^{4}	$47,400^{3}$	0.35^{3}	1.42^{3}
7	2748^{1}	$47,500^{2}$	0.70^{2}	2.00^{1}
9[b]	2789^{4}	$60,000^{2}$	1.65^{3}	1.98^{2}
10-1/2[a]	2681^{3}	$45,600^{3}$	1.10^{3}	1.48^{2}

NOTE: Numerical superscripts indicate number of values constituting average.

a indicates one pressure-time trace missed due to long propellant ignition time.

b indicates two pressure-time traces missed due to long propellant ignition time.

While ignition and complete consumption (with no organic residue) were obtained with all firings, an increase in propellant ignition time was noted. Starting with the six months' exposure condition, some cartridges yielded propellant ignition times exceeding the time sweep of the conventional pressure-time trace, with the result that those traces were not recorded. This increase in propellant ignition time may be due to absorption and retention of a small amount of water by the molded charge.

Thus, the results indicate the molded charge has a considerable degree of inherent moisture resistance. While evaluation of the properties of a coating for combustible ammunition will still include capability of protection against humid environmental conditions, it appears that such protection can easily be furnished.

CURRENT AND FUTURE DEVELOPMENT PROGRAM

The above described studies have resulted in the development of a combustible 7.62 mm cartridge consisting of a molded integral propellant charge (i.e., no loose propellant) and a dual combustible ignition system. This cartridge is illustrated in Figure 7. When used in a self-obturating test weapon, this cartridge yielded mean ballistic performance similar to that obtained with the standard 7.62 mm cartridge.

Work is currently in progress on the development of a modified self-obturating M14 rifle compatible with the combustible ammunition. Obturation is obtained by a metal cup, attached to the bolt face of the rifle, which seals the chamber immediately prior to ignition. Preliminary firings of the combustible ammunition have been conducted with this rifle. Reliable ignition, complete consumption, and indications of improved velocity uniformity have been obtained. Work is also in progress on the development of a noncorrosive primer mixture (based on lead styphnate, tetrazene, barium nitrate, and antimony sulfide) which will replace the dual primer described in this report. Composition is being varied to attain a mixture of the desired sensitivity.

It is planned to evaluate various molded charge coatings to determine those offering optimum thermal protection. Tests will also be conducted to determine the capability of combustible ammunition to withstand both rough handling and the severe forces to which it would be subjected in an automatic weapon.

Neg 36.231.S1851/ORD.61

Complete Round C~oss Section

Figure 7. Caseless 7.62 mm Ammunition

CONCLUSIONS

1. Combustible 7.62 mm ammunition, consisting of a molded integral propellant charge and a dual primer, was developed. When fired in a self-obturating 7.62 mm test weapon over the temperature range -65° to 160° F, this cartridge yielded mean ballistic performance similar to that obtained with the standard M59 metal cased cartridge. Velocity reproducibility, however, was poorer than that obtained with the standard cartridge. Accuracy was slightly less with the combustible ammunition.

2. The combustible dual primer which consisted of a percussion sensitive cap and a pellet of standard styphnate primer mixture, provided adequate and reproducible ignition. Previous attempts to develop a combustible primer based upon the conventional cup and anvil system were unsuccessful.

3. Molded charges were found to have a considerable degree of inherent moisture resistance. Water immersion tests revealed no substantial changes in velocity or pressure after ten months exposure. Firings were conducted with molded charges coated with various materials to determine the degree of consumption of the coatings. All coatings were consumed, leaving no significant deposits. Impact of 7.62 mm rifle bullets did not cause deflagration of combustible cartridges.

4. Mechanical testing of molded charges was conducted to determine single shear, tensile, and compression strength. The effect of temperature on dimensional changes was found to be sufficiently small, indicating this does not constitute a serious problem.

APPENDIX

PROPELLANT DESCRIPTION SHEET

Supersedes OO Form ... dated 1 Jul. 47 which is obsolete.

Lot No. IA- 41024 of 1953 Composition No. IMR 4895 For Cal. .30

Manufactured at: Indiana Arsenal, I.O.W., Charlestown, Indiana Packed Weight 42,950 lbs.
Contract No. DA-11-173- ORD-154 Date Jan. 3, 1952 Specification No. JAN-P-733 Amendment 2.

NITROCELLULOSE Cotton Linters May 24, 1950

Accepted blends (nos.) I.O.W.-F- 2129; F- 2400, 2402, 2404, 2405, 2406, 2408, 2409, 2410, 2412, 2391, 2398

Nitrogen Content		K.I. Starch Test (65.5° C.)		Stability Test (135° C.)	
Maximum	13.17 %	Maximum	45+ mins.	Maximum	45 Mins.
Minimum	13.12 %	Minimum	40 Mins.	Minimum	30 Mins.
Average	13.14 %	Average	45+ mins.	Average	35 Mins.
				Explosion	Mins.

MANUFACTURE OF PROPELLANT

Total weight of solvent per pound NC 0.94 Consisting of 35 pounds alcohol and 65 pounds ether per 100 pound solvent. Percentage of remix to whole None

Temps. °C. From	Temps. °C. To	Process—Solvent Recovery and Drying	Times Days	Times Hours
35	55	Solvent recovery - raise 5° C per hour - hold for 26 hours at 55° C		30
60	60	Water dry before coating	8	
60	60	Water dry after coating		24
55	55	Air dry		11

TESTS OF FINISHED PROPELLANT

COMPOSITION

Constituent	Formula	Mfr.	Inspr.
Nitrocellulose	100.00		
Pot. Sulfate (added)	1.35	0.61	
Diphenylamine (added)	0.70	0.80	.70
DNT (coated)		6.90	
Graphite (glazed)			
Total Volatiles / Solvents		0.70	.66
Moisture, Distillation		0.92	.91
Ash		[illegible]	
Dust & Foreign Mat.		0.016	

STABILITY AND PHYSICAL TESTS

	Mfr.	Inspr.
135° C heat test, S. P.	50	50 Min.
Explosion	5+	5 Hrs.+
Form of grain	Cylindrical	
No. of perforations	1	1
No. of grains per pound	395,719	
Burning surface per pound (sq. inches)		
Grav. density, or pounds per cu. ft.	.915	.920
Specific gravity		
Hygroscopicity		
Compression test		

Grain Dimensions	Die (Inches)	Finished Grain (Inches) Manufacturer	Finished Grain (Inches) Inspector	Mean Variation in Per Cent of Mean Dimension Manufacturer	Mean Variation in Per Cent of Mean Dimension Inspector
Length (L)	0.0625	0.0577			
Diameter (D)	0.0490	0.0329			
Diameter of perforations (d)	0.0150	0.0073			
Web: Inner					
Web: Outer					
Web: Average		0.0126			
Web: Calculated					
Difference between inner and outer web in per cent of web average					
L/D (f)		1.75			
D/d (f)		4.51			

Date packed AUG. 22, 1953 Date offered AUG. 20, 1953 Date sampled 20 August 1953
Date test finished 2 September 1953 Date description sheets forwarded 4 September 1953
Type of Packing Box Box, packing, wood-copper-lined (reconditioned) 24, Dwg. No. 76-4-46
Remarks This lot meets chemical and physical requirements.

ROBINSON, JARGER

Signature	Inspector of Ordnance, by	U.S. Govt.
[illegible] Tech. Dept.	H. MINNEY	[illegible]

REFERENCES

1. Frankford Arsenal Report R-1552, "Combustible Ammunition for Small Arms. I. Development of Self-Contained Propellant Charge." J. B. Quinlan, E. F. Van Artsdalen, and M. E. Levy, May 1960.

2. Bureau of Mines, Report 3794, "Report of Explosibility Tests on Three Samples of Experimental Caseless Ammunition," 2 November 1960.

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Research and Development Group, Pitman-Dunn Laboratories, FRANKFORD ARSENAL, Philadelphia 37, Pa.
COMBUSTIBLE AMMUNITION FOR SMALL ARMS. II. DEVELOPMENT OF A COMBUSTIBLE SMALL ARMS CARTRIDGE
by E. F. VanArtsdalen, M. E. Levy, and J. B. Quinlan

Technical Report R-1643, Jun 62; 37 pp incl tables and illus. OMS Code 5530.11.553 (TS1-2); DA Proj 504-03-002
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UNCLASSIFIED

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2. Ammunition, Combustible
3. Small Arms
4. Propellant, Solid
5. Primer, Combustible

I. VanArtsdalen, E. F.
II. Levy, M. E.
III. Quinlan, J. B.
IV. OMS Code 5530.11.553 (TS1-2)

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III. Quinlan, J. B.
IV. OMS Code 5530.11.553 (TS1-2)

DISTRIBUTION LIMITATIONS:
None; obtain copies from ASTIA.

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AD- ACCESSION NO.
R-1643
Research and Development Group, Pitman-Dunn Laboratories, FRANKFORD ARSENAL, Philadelphia 37, Pa.
COMBUSTIBLE AMMUNITION FOR SMALL ARMS. II. DEVELOPMENT OF A COMBUSTIBLE SMALL ARMS CARTRIDGE
by E. F. VanArtsdalen, M. E. Levy, and J. B. Quinlan

Technical Report R-1643, Jun 62; 37 pp incl tables and illus. OMS Code 5530.11.553 (TS1-2); DA Proj 504-03-002
UNCLASSIFIED REPORT

Combustible 7.62 mm ammunition, consisting of a molded integral propellant charge and a dual primer, was developed. When fired in a self-obturating test weapon, it yielded ballistic performance similar to that obtained with standard M59 metal cased cartridges, but velocity reproducibility and accuracy were poorer.

The combustible dual primer, which consisted of a percussion sensitive cap and a pellet of standard styphnate primer mixture, provided adequate and reproducible ignition. Molded charges were found to have a considerable degree of inherent moisture resistance. Firings conducted with molded charges coated with various materials indicated that all coatings were consumed, leaving no significant deposits. Single shear, tensile, and compression strength and the effect of temperature on dimensional changes were determined. Impact of 7.62 mm rifle bullets did not cause deflagration of combustible cartridges.

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1. Ammunition, Caseless
2. Ammunition, Combustible
3. Small Arms
4. Propellant, Solid
5. Primer, Combustible

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